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FINAL REPORT  
Highly Ionized Spectra of  
Nitrogen and Oxygen

Kjell Bockasten  
Physics Department  
University of Uppsala  
UPPSALA, Sweden

# Highly Ionized Spectra of Nitrogen and Oxygen.

(K. Bockasten, J. Bromander, R. Hallin, B. Johansson).

The investigations have been carried out during the period 1 December 1963 - 31 May 1966.

The spectra of N V, N IV, O V, O IV, and O III have been investigated in the wavelength region 250 - 8500 Å. The spectra have been obtained from a theta-pinch discharge, developed for spectroscopic purposes. A description of this light source has been published in a paper by Kjell Bockasten, Reinhold Hallin, and N. Robert Nilsson: A theta-pinch discharge as spectroscopic light source, Arkiv Fysik 32, 437 (1966). (25 copies are enclosed.)

A total of about 1400 spectrograms have been taken at different conditions. In the wavelength region 250 - 2200 Å a 3-metre Hilger normal incidence vacuum spectrograph was used with Bausch and Lomb replica gratings with 1200 lines per mm, one blazed at 1500 Å and another at 1200 Å. In the wavelength region 2200 - 8500 Å a 2-metre Ebert spectrograph was used. It was built at the Nobel Institute for Physics and several gratings were used, all of them ruled at M. Siegbahn's institute.

Exposures taken with various discharge voltages and various pressures in the discharge tube makes it possible to sort the lines after ionization stage. Plates taken with various filling gases, usually oxygen or nitrogen, have been used to sort out impurities from the tube material, which come out equally strong independent of what filling gas we have. Finally we have used different materials for the discharge tube, namely pyrex, quartz, <sup>and</sup> alumina. This facilitates the sorting out of impurity lines from the walls.

For identification purposes we have first taken as clean spectrograms as possible from the elements we want to investigate. After that we introduce various gases, such as He, Ne, Ar, and CO<sub>2</sub>, in order to get suitable reference lines. The reference spectra have been excited either by an rf-oscillator or with the θ-pinch discharge.

The spectrograms have been compared two and two in a Hilger comparator Model L 150. They have then been measured in an Abbe comparator (Model B, Carl Zeiss, Jena). Since May 1965 a photo-

electric device has been used for setting the lines under the microscope. The scale for reading the position of the table is projected onto a screen for easier reading. This equipment gives higher accuracy of the measured lines.

A problem in the normal incidence vacuum region is the overlapping of spectral orders. This difficulty has been overcome by absorption of unwanted spectral orders by a few mtorr of helium or argon in the vacuum spectrograph. The procedure is described in the paper about the light source.

The analysis of the wavelength material has been completed for N V and N IV. Descriptions of these spectra are given in the following two papers: Reinhold Hallin, The Spectrum of N V, Arkiv Fysik 31, 511 (1966) (25 copies are enclosed.), Reinhold Hallin, The Spectrum of N IV, Arkiv Fysik 32, 201 (1966). (25 copies are enclosed.)

The first gives a complete description of the N V spectrum. From the experimentally determined term levels the ionization limit has been determined to  $789537.2 \pm 3.0 \text{ cm}^{-1}$ . The term series are represented by series formulae, from which calculated values of unknown term levels have been computed. For hydrogenlike term levels the formulae give in principle unperturbed values, while the observations are affected by Stark effect. The differences between observed and calculated hydrogenlike levels have been compared to Stark effect displacements, calculated for different field strengths.

The second paper gives a description of the N IV spectrum. A large number of new lines have been observed, two of which are intercombination lines, connecting the singlet and triplet systems. The intercombination lines show that the triplet levels given in Atomic Energy Levels (Ch.E. Moore, Nat. Bur. Stand. Circ. 467, Vol I, 1949) should be increased by  $73 \text{ cm}^{-1}$  relative to the singlets. The whole term system has been recalculated by the method of least squares on the basis of the new measurements and a few lines by Edlén in the wavelength region 303 - 387 Å. The ionization limit has been determined to  $624864.7 \pm 2.0 \text{ cm}^{-1}$ .

In N VI three lines have been reported in Phys. Letters 8, 181 (1964).

For O V, O IV, and O III wavelength lists have been given in the quarterly reports as follows: O V in Status Report No. 8, O IV in Status Report No. 7, and O III in Status Report No. 1 (Phys. Letters 8, 181, 1964). For these spectra the analyses are not completed yet. Complete descriptions of these spectra will be published in Arkiv Fysik. Preprints will be sent to the Grants and Research Contracts Division as soon as the work has been completed.